

Attorney Docket No. OUTO 2437
Express Mail
Label No: EL888470255
Date of Deposit: 3/15/02

CHAPTER II

TRANSMITTAL LETTER TO THE UNITED STATES ELECTED OFFICE (EO/US)

(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

<u>PCT/FI00/00834</u>	<u>29 September 2000 (29.09.00)</u>	<u>30 September 1999 (30.09.99)</u>
INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

A COMPACT CASCADE SCRUBBER FOR SCRUBBING EXHAUST GAS

TITLE OF INVENTION

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APPLICANT(S)

Box PCT
ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Attention: EO/US

1. This national phase application claims priority of the following national application(s):

Finnish Patent Application No. 19992097 filed September 30, 1999.
2. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 USC 371:
 - A. ☒ This express request to immediately begin national examination procedures (35 USC 371(f)).
 - B. ☒ The U.S. National Fee (35 USC 371(c)(1) and other fees (37 CFR 1.492) indicated in the attached fee calculation sheet.
3. ☒ A copy of the International application as filed [35 USC 371(c)(2)]:
 - a. ☐ is transmitted herewith.
 - b. ☐ is not required as the application was filed with the United States Receiving Office.

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- c. ☒ [x] has been transmitted
- i. ☒ [x] by the International Bureau. Date of mailing of the application (from form PCT/IB/308): 05 April 2001 (05.04.01).
- ii. ☐ [] by applicant on (date) _____.
4. ☒ [x] A translation of the International application into the English language [35 USC 371(c)(2)]:
- a. ☐ [] is transmitted herewith.
- b. ☒ [x] is not required as the application was filed in English.
- c. ☐ [] was previously transmitted by applicant on (date) _____.
- d. ☐ [] will follow (within 32 months of earliest priority date).
5. ☒ [x] Amendments to the claims of the International application under PCT Article 19 [35 USC 371(c)(3)]:
- a. ☐ [] are transmitted herewith.
- b. ☐ [] have been transmitted
- i. ☐ [] by the International Bureau. Date of mailing of the amendment (from form PCT/IB/308): _____.
- ii. ☐ [] by applicant on (date) _____.
- c. ☒ [x] have not been transmitted as
- i. ☒ [x] applicant chose not to make amendments under PCT Article 19. Date of mailing of Search Report (from form PCT/ISA/210): 15 January 2001 (15.01.01).
- ii. ☐ [] the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.
6. ☒ [x] A translation of the amendments to the claims under PCT Article 19 [35 USC 371(c)(3)]:
- a. ☐ [] is transmitted herewith.
- b. ☐ [] is not required as the amendments were made in the English language.
- c. ☒ [x] has not been transmitted for reasons indicated at point 5c above.

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7. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409)
 - a. ☒ is transmitted herewith.
 - b. ☐ is not required as the application was filed with the United States Receiving Office.
8. ☒ Annex(es) to the International Preliminary Examination Report
 - a. ☒ is/are transmitted herewith.
 - b. ☐ is/are not required as the application was filed with the United States Receiving Office.
 - c. ☐ is/are not being transmitted as there is/are no Annex(es).
9. ☒ A translation of the annexes to the International Preliminary Examination Report
 - a. ☐ is transmitted herewith.
 - b. ☒ is not required as the annexes are in the English language.
 - c. ☐ is not being transmitted for the reason indicated at point 8c above.
10. ☒ An oath or declaration of the inventor [35 USC 371(c)(4)] complying with 35 USC 115
 - a. ☐ was previously submitted by applicant on (date) _____.
 - b. ☐ is submitted herewith and such oath or declaration
 - i. ☐ is attached to the application
 - ii. ☐ identifies the application and any amendments under PCT Article 19 which were transmitted as stated in points 5a or b; and states that they were reviewed by the inventor as required by 37 CFR 1.70.
 - c. ☒ will be provided in response to a Notice to File Missing Requirements.
11. ☒ An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):
 - a. ☐ is transmitted herewith.
 - b. ☒ has been transmitted by the International Bureau. Date of mailing (from form PCT/IB/308): 05 April 2001 (05.04.01).
 - c. ☐ is not required as the application was searched by the United States International Searching Authority.
 - d. ☐ will be transmitted promptly upon request.

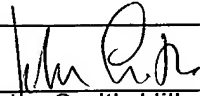
- e. ☐ has been submitted by applicant on (date) _____.
12. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98:
- a. ☐ is transmitted herewith.
- Also transmitted herewith is
- ☐ Form PTO-1449
- ☐ Copies of citations listed
- b. ☐ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 USC 371(c).
- c. ☐ was previously submitted by applicant on (date) _____.
13. ☐ The applicant claims small entity status with respect to this application.
- ☐ A Verified Statement Claiming Small Entity Status is attached.
- ☐ The undersigned claims small entity status on behalf of the applicant.
14. ☐ An assignment document is transmitted herewith for recording. A separate ☐ "RECORDATION COVER SHEET" is also attached.
- _____
- _____
- _____
15. ☒ Additional documents
- a. ☐ Copy of request (PCT/RO/101)
- b. ☒ International Publication No. WO 01/23071
- i. ☐ Specification, claims and drawing
- ii. ☒ Front page only
- c. ☐ Preliminary amendment
- d. ☒ Abstract
- e. ☐ Other
- _____
16. ☒ The above checked items are being transmitted
- a. ☒ before 30 months from any claimed priority date.

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- b. ☐ after 30 months but before 32 months (surcharge and/or processing fee included) from any claimed priority date.

17. ☐ Certain requirements under 35 USC 371 were previously submitted by the applicant on _____, namely:



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FEE CALCULATION SHEET

Entry into National Phase of PCT/FI00/00834

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
* []	TOTAL CLAIMS 14	-20 =	0	x \$ 18 =	\$ 0
	INDEPENDENT CLAIMS 1	- 3 =	0	x \$ 84 =	\$ 0
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$280 =	\$ 0
BASIC FEE	[] U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: [] and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(1) to (4) have been satisfied for all the claims presented in the application entering the national state (37 CFR 1.492(a)(4)) \$100 [] and the above requirements are not met (37 CFR 1.492(a)(1)) \$710 [x] U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO. [] has been paid (37 CFR 1.492(a)(2)) \$740 [x] has not been paid (37 CFR 1.492(a)(3)) \$1,040 [] where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) \$890				1,040
OTHER FEES	Surcharge of \$130 for furnishing the oath or declaration later than 30 months (but no later than 32 months) from any claimed priority date (37 CFR 1.492(e) and 37 CFR 1.495(c)). Total of above Calculations				+ = 1,040
SMALL ENTITY	Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed also. (note 37 CFR 1.9, 1.27, 1.28) Subtotal				- 1,040
	Processing fee of \$130 for furnishing the English Translation later than 30 months (but not later than 32 months) from any claimed priority date (37 CFR 1.492(f) and 37 CFR 1.495(c)). Basic National Fee				+ \$ 1,040
	Fee for recording the enclosed assignment document \$40 (37 CFR 1.21(h)).				+ \$ 1,040
TOTAL	TOTAL FEES ENCLOSED				\$ 1,040

* See attached Preliminary Amendment.

- [X] A check in the amount of \$1,040 to cover the above fees is enclosed.
- [X] Please charge any additional **basic** filing fee under 37 CFR 1.492(a) which may be required by this paper, or credit any overpayment to Deposit Account No. 19-2560. (**Do not charge additional claim fees under 37 CFR 1.492(b) or 1.492(c) or the surcharge for belated filing of the Declaration under 37 CFR 1.492(e) to the Deposit Account.**) This sheet is filed in duplicate.

Penelope Stockwell

10/088566

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FEE CALCULATION SHEET

Entry into National Phase of PCT/FI00/00834

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
* <input type="checkbox"/>	TOTAL CLAIMS 14	-20 =	0	x \$ 18 =	\$ 0
	INDEPENDENT CLAIMS 1	- 3 =	0	x \$ 84 =	\$ 0
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$280 =	\$ 0
BASIC FEE	<input type="checkbox"/> U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO <input type="checkbox"/> and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(1) to (4) have been satisfied for all the claims presented in the application entering the national state (37 CFR 1.492(a)(4)) \$100 <input type="checkbox"/> and the above requirements are not met (37 CFR 1.492(a)(1)) \$710 <input checked="" type="checkbox"/> U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: <input type="checkbox"/> has been paid (37 CFR 1.492(a)(2)) \$740 <input checked="" type="checkbox"/> has not been paid (37 CFR 1.492(a)(3)) \$1,040 <input type="checkbox"/> where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) \$890				1,040
OTHER FEES	Surcharge of \$130 for furnishing the oath or declaration later than 30 months (but not later than 32 months) from any claimed priority date (37 CFR 1.492(e) and 37 CFR 1.495(c))				+
	Total of above Calculations				= 1,040
SMALL ENTITY	Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed also (note 37 CFR 1.9, 1.27, 1.28)				-
	Subtotal				1,040
	Processing fee of \$130 for furnishing the English Translation later than 30 months (but not later than 32 months) from any claimed priority date (37 CFR 1.492(f) and 37 CFR 1.495(c))				+
	Basic National Fee				\$ 1,040
	Fee for recording the enclosed assignment document \$40 (37 CFR 1.21(h))				+
TOTAL	TOTAL FEES ENCLOSED				\$ 1,040

* See attached Preliminary Amendment.

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☒ Please charge any additional basic filing fee under 37 CFR 1.492(a) which may be required by this paper, or credit any overpayment to Deposit Account No. 19-2560. (Do not charge additional claim fees under 37 CFR 1.492(b) or 1.492(c) or the surcharge for belated filing of the Declaration under 37 CFR 1.492(e) to the Deposit Account.) This sheet is filed in duplicate.

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ABSTRACT

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This invention relates to a cascade-type scrubber, with which the wet scrubbing of the exhaust gas and removal of droplets from the gas can be performed in one and the same scrubber, producing a pure, dropless gas. It is thus essential that the cascade tubing typical of the cascade scrubber and the equipment for droplet removal are combined into a single compact entity, which is formed of several nested chambers.

A COMPACT CASCADE SCRUBBER FOR SCRUBBING EXHAUST GAS

This invention relates to a cascade-type scrubber, with which the wet scrubbing of the exhaust gas and removal of droplets from the gas can be performed in one and the same scrubber, producing a pure, dropless gas. It is thus essential that the cascade tubing, typical of the cascade scrubber and the equipment for droplet removal are combined into a single compact entity, which is formed of several nested chambers.

Cleaning of gases can in principle be divided into two stages, the actual scrubbing and the subsequent droplet separation. One scrubber type used extremely often is the venturi scrubber and another is the cascade scrubber.

In a cascade scrubber (e.g. Bauart BACHO), the gas to be scrubbed is sucked in reduced pressure into a series of cascade tubes. The gas is injected via the central cascade tube into the scrubbing liquid and sucked from there upward through an annular tube around the central tube. The gas, which has taken the liquid with it, is allowed to collide with a plate surrounding the central tube, which directs the gas downward again. Thus the "self-droplet formation" of the liquid is achieved, and as a result the final scrubbing of the gas occurs. Droplet separation takes place in a separate droplet separator.

Different types of droplet separators are described in the literature e.g. H. Bauer, Y.B.G. Varma: "Air Pollution Control Equipment", Springer-Verlag 1981. pp. 219 - 239. The main types of droplet separators are the zigzag channel, centrifugal or classic filter principles.

According to this invention a compact cascade scrubber is formed essentially of a cylindrical apparatus, where the gas scrubbing equipment is located in the outer section and the droplet separation equipment in the

In the embodiment of the invention all the gas is conducted first to a common chamber, from where it is divided into several scrubbing units. Naturally successful distribution depends on the construction of the distribution chamber. One distribution method, well known from air-conditioning technology, is changing the cross-section of the flow in the flow direction. A typical method is to use a sloping bottom in the annular distribution chamber. It is also advantageous for the droplet separator if the scrubber has only one discharge channel, in other words, the sub-flows of gas from the cascade tubes are combined after scrubbing at least twice. The first time is immediately after the scrubbing in the cascade tubes in the annular chamber

situated below the gas distribution chamber. After combining the gas flows the gas is separated in the next annular chamber into sub-flows, which are then recombined to flow into the droplet separator.

- 5 Symmetry and the use of essentially cylindrical walls are typical of a scrubber according to this invention. This is significant especially for reasons of strength, because a reduced pressure is used in most scrubbers, and the above-mentioned properties prevent the collapse of the scrubber when using reduced pressure. The actual scrubbing occurs best in a
- 10 reduced pressure - i.e. the gas can reach a suitable velocity with a blower located after the scrubber. It is clear that scrubbing also functions under pressure, but it is not beneficial for the blower to feed hot and dirty gas through it.
- 15 In the apparatus according to the present invention, the cascade scrubbing units are similar and placed symmetrically, thus aiming at optimal gas distribution. If some of the scrubbing units are shut, it is also beneficial to do this symmetrically. The scrubbed gas in the cascade tubes is conducted tangentially along several channels to the following inner, annular space,
- 20 where the sub-flows of gas are combined.

The invention is described further in the attached drawings, where Figure 1 presents cascade scrubbers of the prior art, Figure 2 presents the general principle of one embodiment of the invention

25 in a partially cut drawing, Figure 3A is a vertical section and Figure 3B a cross-section of one scrubber according to the invention, Figure 4 is a vertical section of another embodiment of the invention where the bottom of the droplet separator swirl chamber has been raised,

30 Figures 5A and 5B are further vertical and cross-sections of a scrubber that has been modified to reduce its diameter,

Figure 6 shows a scrubber, where the upper cover of the droplet separator has been lowered,

Figures 7A and 7B are a vertical and cross-section of a scrubber according to the invention, where the bottom of the annular chamber has been shaped,

5 Figure 8 shows a cross-section of a scrubber where the cascade tubes are located in several circles, and

Figure 9 shows a cross-section where the cascade tubes have been shaped.

Figure 1 presents an exhaust gas scrubbing apparatus of the prior art,
10 comprising a scrubbing section 1 and a separate droplet separation unit 2. Several cascade tubes 3 are located inside the scrubber and the gas scrubbing water is discharged into a tank 4 in the lower section of the scrubber. A single cascade tube consists of an inner tube 5, an outer tube 6 around it and a collision plate 7 placed around the inner tube. The gas
15 routed to the scrubber is conveyed into the inner tube 5 of the cascade tube and from there to the outer tube 6 around and under said tube where it can be injected into the water surface in the outer tube. The gas, partially scrubbed and carried away with droplets from the water, rises upwards inside the outer tube and comes into contact with a dish-like collision plate 7,
20 which changes the direction of the gas downwards again. After colliding and bending, the direction of the gas once more turns outwards and the gas is vented through a connecting tube 8 from the scrubbing unit into the droplet separation unit, where the droplets attached gas during scrubbing are separated and the scrubbed gas is discharged from the unit.

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The principle figure 2 of the scrubber according to the present invention shows that a scrubber 10 is essentially cylindrical in cross-section at the scrubber and droplet separator sections and conical at the bottom section. The gas to be scrubbed enters the scrubber via an inlet channel 9 and the
30 scrubbed gas is vented via a droplet separator unit discharge tube 11 inside the scrubber. As the partially opened drawing shows, there are several

cascade tubes 12 in the circle of the lower section of the scrubber. The surface 14 of the scrubbing water in the water tank 13 in the lower section of the scrubber reaches as far as the cascade tubes. The lower section of the scrubber is preferably conical, whereby the solids to be scrubbed from the gas are more easily removed with the scrubbing water. The figure also shows that the structure of the scrubber is cylindrical and compact and therefore easy to maintain.

The structure of the cascade scrubber according to the invention is shown in more detail in Figures 3A and 3B. The gas inlet channel 9 is connected to an annular gas distribution chamber 15 located around a droplet separation chamber 16 in the top of the scrubber 10. At its lower section the gas distribution chamber is connected to inner tubes 17 of the cascade tubes 12, into which the gas to be scrubbed is discharged from chamber 15. As mentioned in regard to the prior art, the cascade tubes consist in this case too of an inner tube, an outer tube 18 and a dish-like collision plate 19 attached to the inner tube. When the inner tube is positioned at such a height that its lower edge comes below the liquid surface 14, scrubbing efficiency is maximized, but in this case pressure losses also increase. The outer tube surrounds the inner tube in the cascade tube and the upper part comes slightly above the surface of the liquid.

As Figures 3A and 3B also show, the cascade tubes 12 are advantageously located in the outer shell of the scrubber below the gas distribution chamber 15 and inside an outer chamber 20. After the cascade tube collision plate the gas flows upwards in the outer chamber around the cascade tube and at the same time the gas from each cascade tube comes together. In order to separate the droplets of water, which attached to the gas during scrubbing, from the gas it is beneficial to give the gas a whirling motion. For this purpose a chamber is formed in the scrubber, with a partition wall 21 such that at the bottom towards the outer chamber the partition is integral, but at

the top annular chamber 22 is divided with tangentially placed partition walls 23 into segments 24. The number of segments is advantageously at the most half the number of cascade tubes. With the help of partitions 23 the gas, made a uniform flow in the outer chamber, is divided into sub-flows
5 which are made to swirl with help of the partitions.

Figures 3A and 3B also show that progressing towards the centre of the scrubber, there is a further annular chamber 25 inside chamber 22 divided into segments. Here in chamber 25 belonging to the droplet separation unit,
10 the separate gas flows coming from the segments 24 of the previous chamber are united again into a uniform tangential flow. Centrifugal force is obtained with the tangential flow, throwing the droplets of liquid contained in the gas against the walls of the chamber, where they flow to the scrubbing liquid in the bottom of the scrubber. The droplet separation capacity of the
15 scrubber is improved when the apparatus comprises several chambers, where the gas is in a whirling motion and in which each subsequent chamber has a smaller cross-sectional area than the previous one.

In addition to gas flow-dividing chamber 22 and recombining chamber 25 the
20 droplet separation unit comprises the droplet separation chamber 16 and the discharge tube 11 as well as a swirl cone 26. The swirl cone 26, which narrows towards the top, is located below the droplet separation chamber just above the surface of the liquid. Its task is to stabilize the gas vortex generated to the centre of the chamber and to prevent the vortex to suck up
25 liquid from the liquid surface into the gas flow entering the droplet separation chamber. The whirling flow of the gas continues in the droplet separation chamber 16 and as a result, a pure, dropless gas is obtained, which is vented via the discharge tube 11. The magnitude of the centrifugal force depends on e.g. the tangential velocity of the gas, which can be adjusted
30 according to the capacity using an adjustment element in inlet channel 9 (not shown in detail in the figure).

The essential difference between the scrubber shown in Figure 3 and the one shown in Figure 4 is that the size of the scrubber can be reduced by raising a lower edge 27 of the droplet separation chamber 16, so that the gas can still flow in the gas flow-combining chamber 25, which has a smaller cross-sectional area than the previous scrubber.

In the embodiments presented in Figures 5A and 5B, in order to decrease the size of the scrubber, the cross-sectional area of the annular outer chamber 20 is reduced in the top of the chamber, because from there the gas can be made to flow to the next inner chamber. Thus the cross-sectional area of the outer chamber can be reduced. The cross-sectional area of the next inner chamber 22 in the direction of the flow has been reduced in the bottom of the chamber, because the separate gas flows flow mainly in the top of the chamber. A change in the cross-sectional area of the chambers is made by altering the construction of the partition 21 between the chambers.

The scrubber construction in Figure 6 is the same type as the one shown in Figures 5A and 5B, but the lower edge 27 of the droplet separation chamber 16 has been further lowered so that the cover section of the scrubber is integral, apart from the discharge tube 11.

Figure 7 shows a scrubber construction where the bottom 28 of the gas distribution chamber 15 has been inclined, so that the cross-sectional area of the distribution chamber reduces as the distance from the inlet channel increases. In this way the velocity of the discharging gas remains the same, although some of the gas is vented into the cascade tubes. The figure also shows that the liquid tank in the lower section of the scrubber can be divided into two parts so that the water used in gas scrubbing can be recovered separately and the droplet separation unit water recovered via a discharge channel 29.

Figures 8 and 9 are cross-sections of embodiments of the present invention, where the cascade tubes are located in the outer chamber in several shells. In the apparatus shown in Figure 9 the outer tube 18 and collision plate 19 of the cascade tube are not circular in cross-section in order to save space. They have a segment missing, from the outer part of the tube and plate in the outer shell and from the inner part in the inner shell.

It is clear that within the sphere of the invention, the alternatives presented above may be modified as required. If for example the scrubber should be as small as possible in cross-section, but space is available in a vertical direction, the droplet separation unit can be arranged vertically without essentially changing the compact structure of the scrubber.

The benefits of the scrubber according to the invention over the prior art include an extremely simple construction, which is thus very easy to maintain as all scrubbing and droplet separation occurs essentially inside a cylindrical structure. Thanks to its cylindrical surfaces the scrubber construction is strong. This is important, because at times the scrubber is subject to a fair degree of reduced pressure, bringing ordinary scrubber close to collapse. The scrubber according to the present invention is not sensitive to changes in capacity, because it is easy to shut off the desired quantity of scrubbing units, the cascade tubes, and the droplet separator can be adjusted according to the capacity by adjusting the cross-section of the inlet channel.

1. A cascade scrubber (10) for scrubbing exhaust gas, whereby the scrubber contains several cascade tubes (12) for scrubbing gas, an inlet channel (9) for conveying the gas to the scrubber, a discharge tube (11) for venting the gas from the scrubber and a liquid tank for scrubbing the gas, **characterized in that** a gas scrubbing unit and a droplet separation unit are combined in the scrubber (10) into a compact apparatus, made up of several nested chambers (20, 22, 24, 16), and that the cascade tubes (12) are placed in an annular outer chamber (20) surrounding said tubes, where the separate gas flows coming from each cascade tube are recombined.

20 3. A cascade scrubber according to patent claim 2, **characterized in that**
the gas distribution chamber (15) surrounds the gas discharge tube (11).

5. A cascade scrubber according to patent claim 5, **characterized in that**
the cross-sectional area of the upper section of the outer chamber (20) is
smaller than that of the lower section.

6. A cascade scrubber according to patent claim 5, **characterized in that** the outer chamber (20) is connected to another annular chamber (22) with the aid of at least partially tangentially positioned partitions (23).
- 5 7. A cascade scrubber according to patent claim 7, **characterized in that** the partitions (23) divide said annular chamber (22) into segments (24), the number of which is advantageously at most half the number of the cascade tubes (12).
- 10 8. A cascade scrubber according to patent claim 7, **characterized in that** the annular chamber (22) containing the partitions (23) is positioned inside the outer chamber (20).
- 15 9. A cascade scrubber according to patent claim 7, **characterized in that** the cross-sectional area of the upper section of the annular chamber (22) is greater than that of the lower section of the chamber.
- 20 10. A cascade scrubber according to patent claim 7, **characterized in that** at least two more nested chambers (25,16) forming the droplet separation unit of the scrubber are positioned inside the chamber (22) containing tangential partitions (23).
- 25 11. A cascade scrubber according to patent claim 1, **characterized in that** the innermost chamber (16) of the droplet separation unit is equipped at the liquid surface (14) with a swirl cone (26) narrowing towards the top.
- 30 12. A cascade scrubber according to patent claim 1, **characterized in that** the innermost chamber (16) of the droplet separation unit is connected to the discharge tube (11) of pure, dry gas.
13. A cascade scrubber according to patent claim 1, **characterized in that** the equipment functions in a reduced pressure.

09-01-2002

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14. A cascade scrubber according to patent claim 1, **characterized in that** the scrubber is essentially cylindrical at the gas scrubbing unit and droplet separation unit and conical at the lower section.

5

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
5 April 2001 (05.04.2001)

PCT

(10) International Publication Number
WO 01/23071 A1

(51) International Patent Classification⁷: **B01D 47/02**

[FI/FI]; Ukonvaaja 6 E 122, FIN-02120 Espoo (FI) NY-
MAN, Bror [FI/FI]; Ruispolku 1, FIN-28450 Vanha-Ulvila
(FI).

(21) International Application Number: PCT/FI00/00834

(22) International Filing Date:
29 September 2000 (29.09.2000)

(74) Agent: **OUTOKUMPU OYJ**; Intellectual Property Man-
agement, P.O. Box 27, FIN-02201 Espoo (FI).

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
19992097 30 September 1999 (30.09.1999) FI

(81) Designated States (*national*): AE, AL, AM, AT, AU, AZ,
BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK,
DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL,
IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU,
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RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA,
UG, US, UZ, VN, YU, ZA, ZW.

(71) Applicant (*for all designated States except US*): **OUT-**
OKUMPU OYJ [FI/FI]; Riihitontuntie 7, FIN-02200 Es-
poo (FI).

(84) Designated States (*regional*): Eurasian patent (AM, AZ,
BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE,
CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC,
NL, PT, SE).

(72) Inventors; and

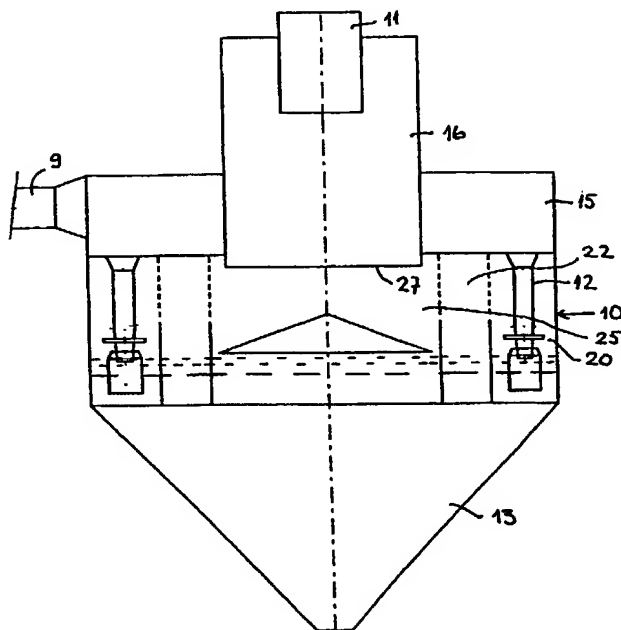
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Published:

— With international search report.

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: A COMPACT CASCADE SCRUBBER FOR SCRUBBING EXHAUST GAS



(57) Abstract: This invention relates to a cascade-type scrubber, with which the wet scrubbing of the exhaust gas and removal of droplets from the gas can be performed in one and the same scrubber, producing a pure, dropletless gas. It is thus essential that the cascade tubing typical of the cascade scrubber and the equipment for droplet removal are combined into a single compact entity, which is formed of several nested chambers.

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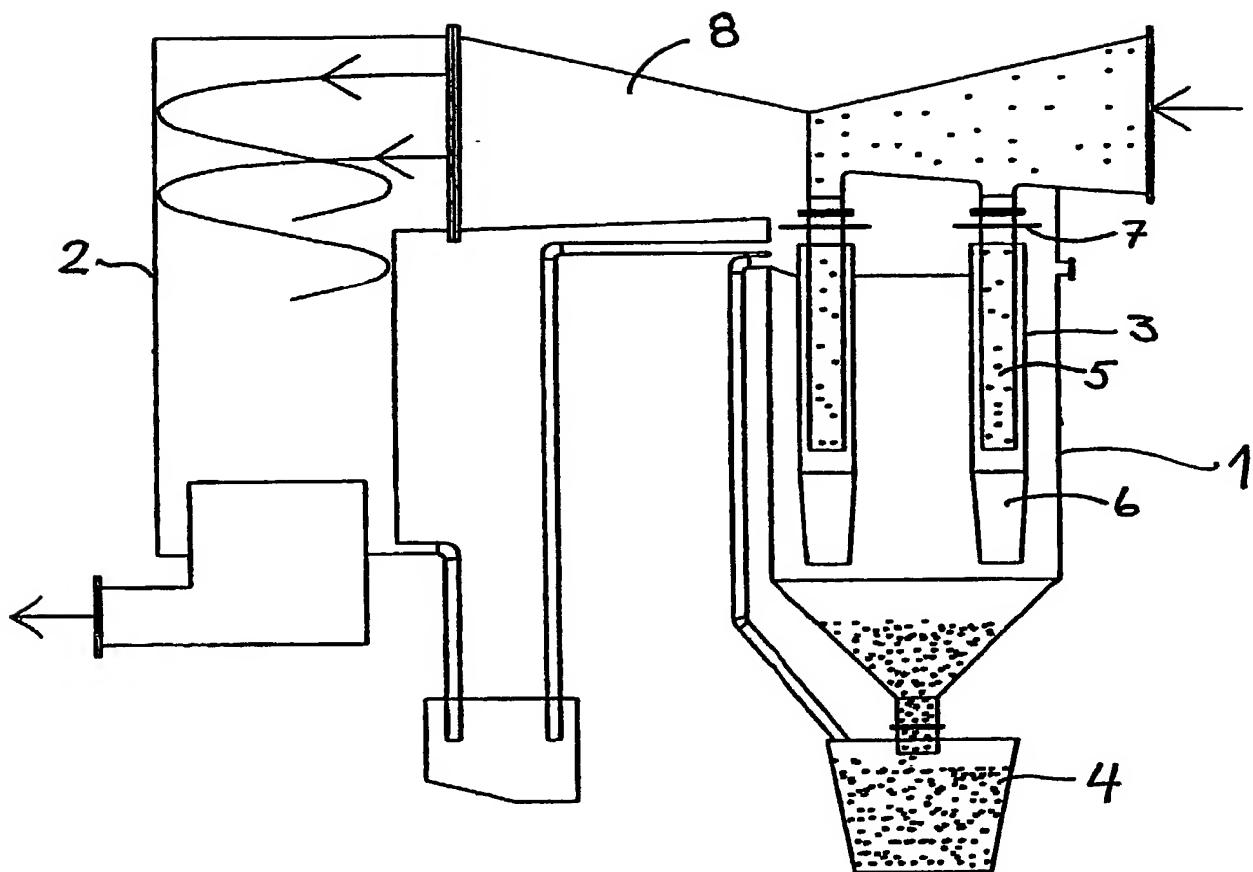
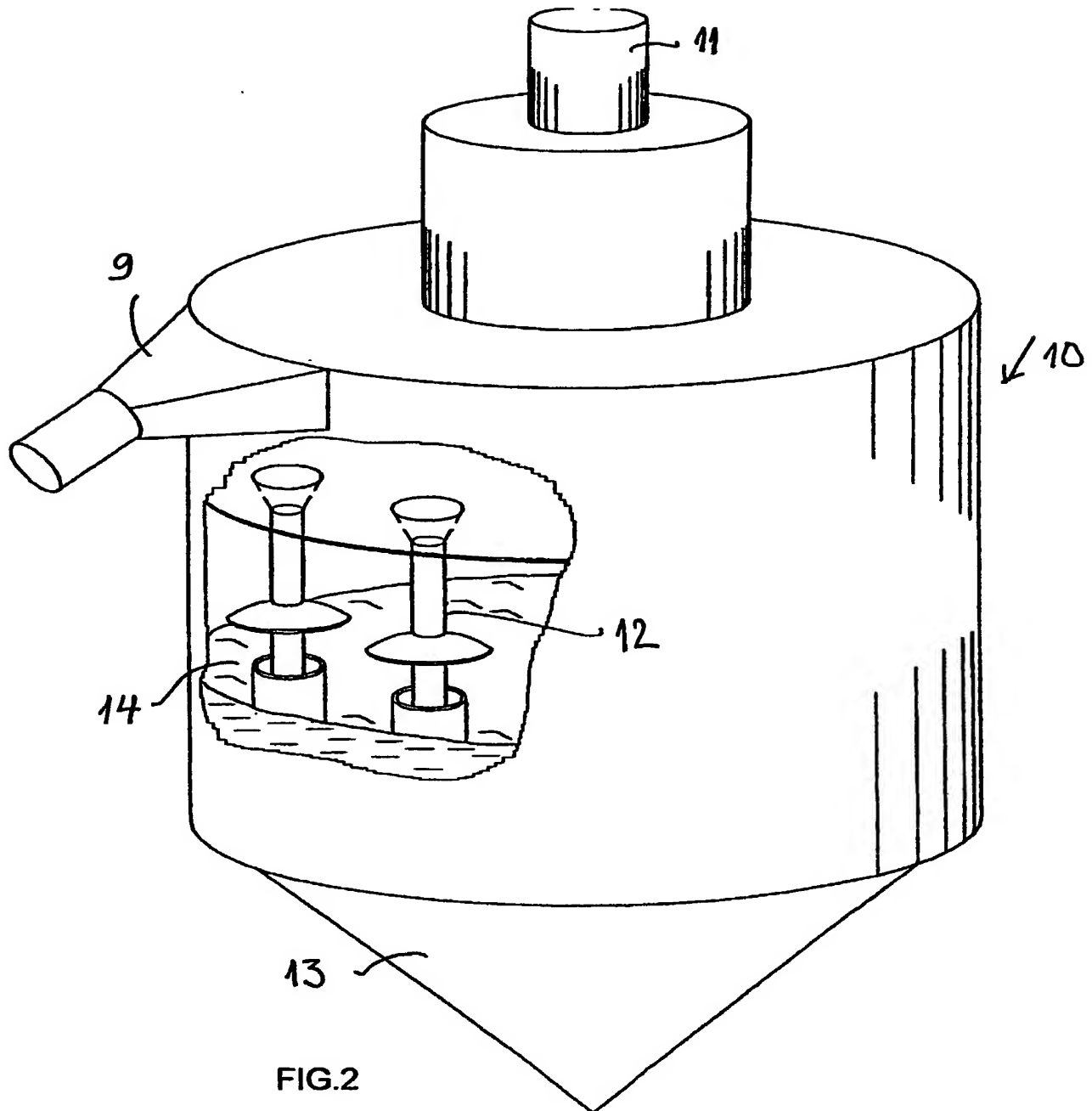
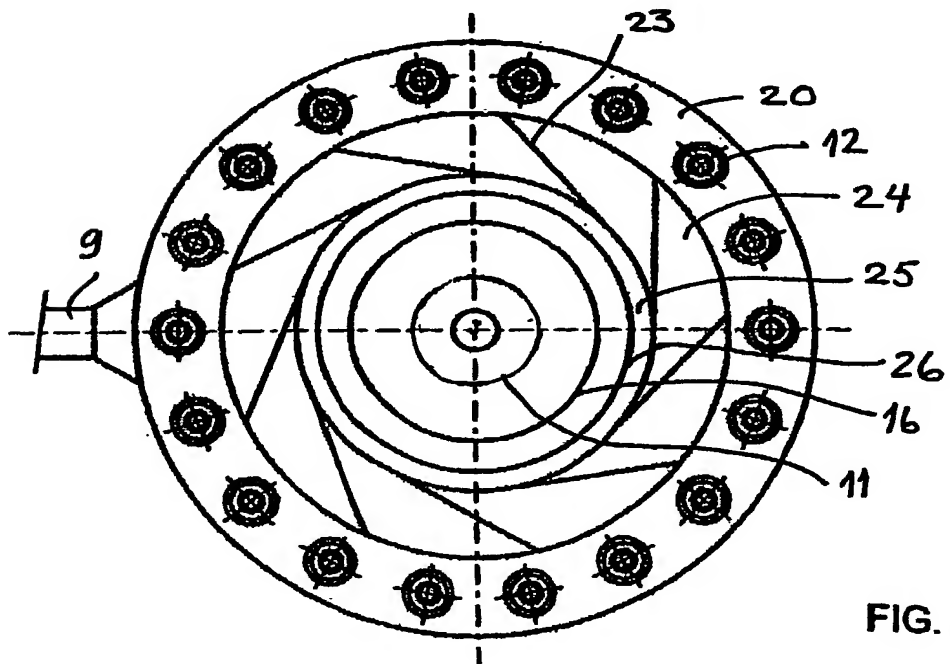
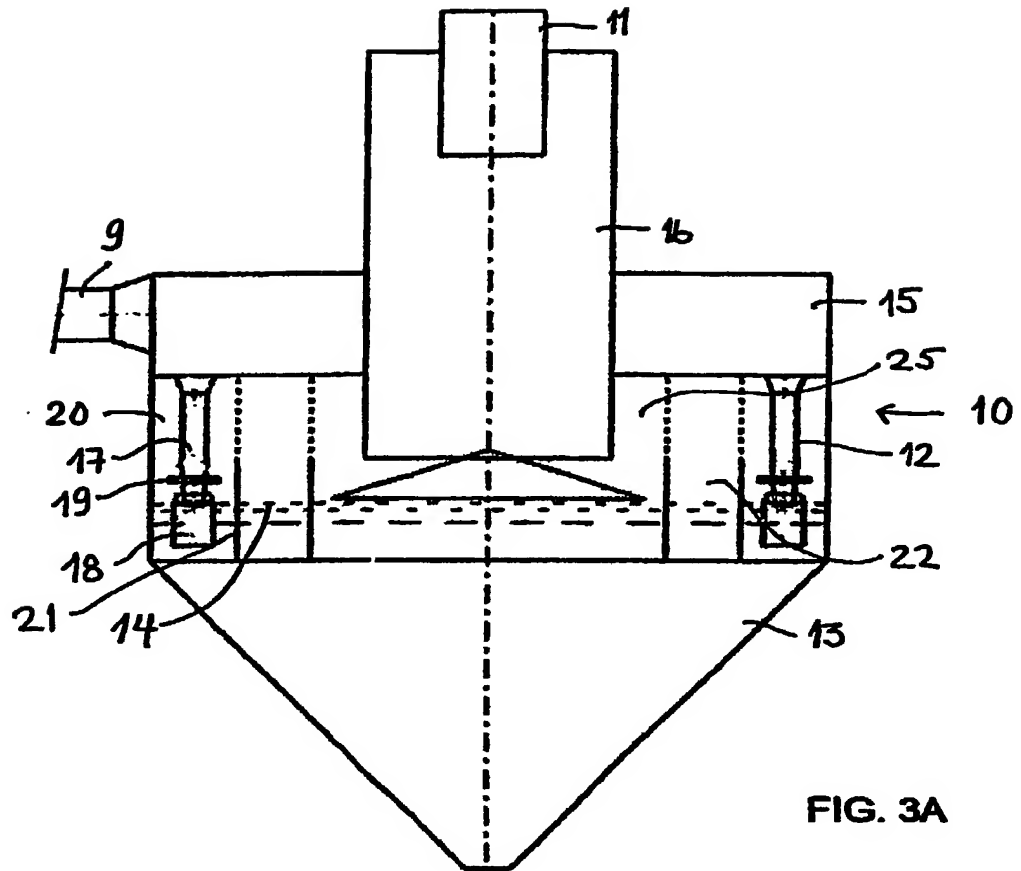


FIG. 1





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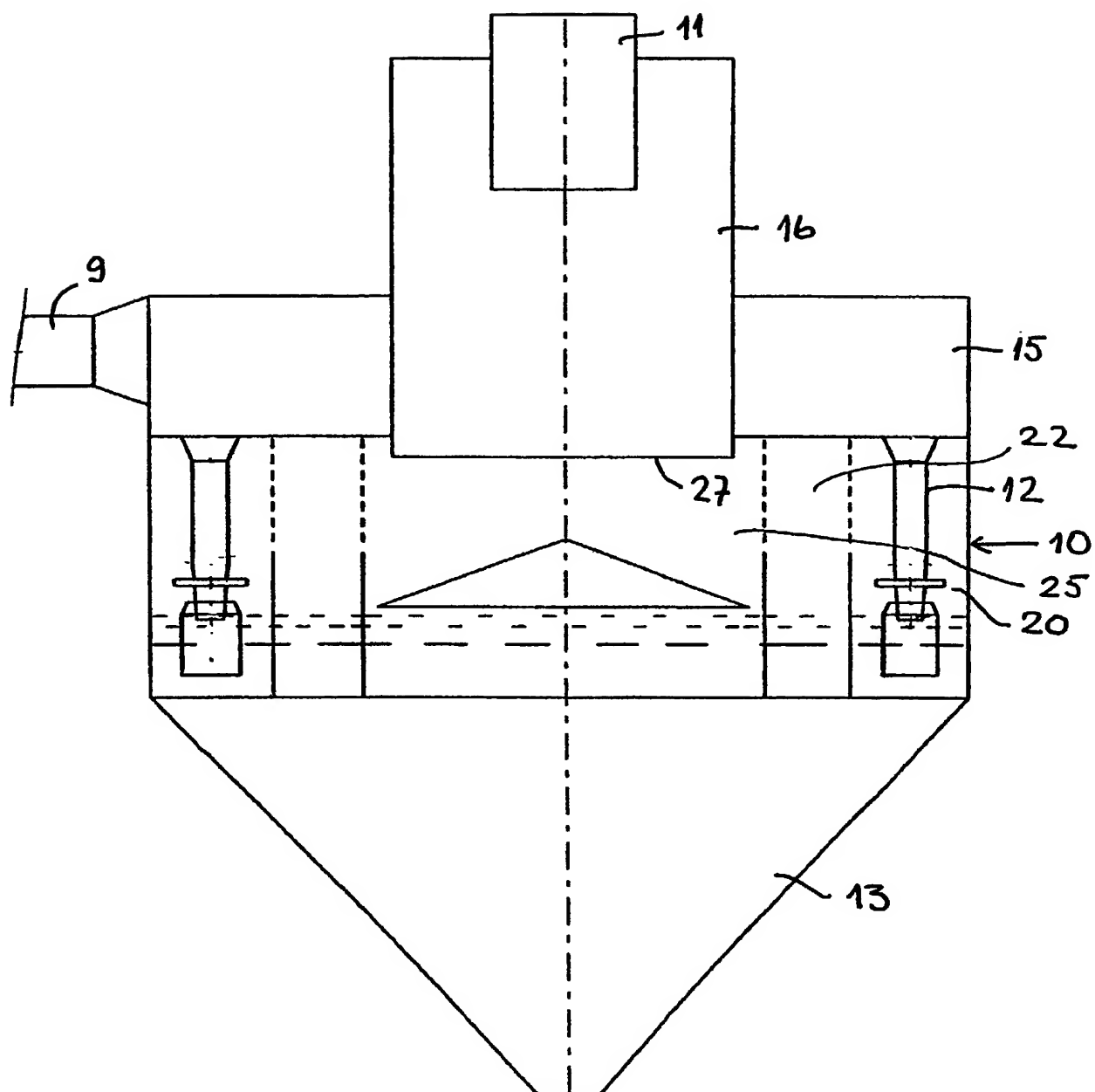


FIG. 4

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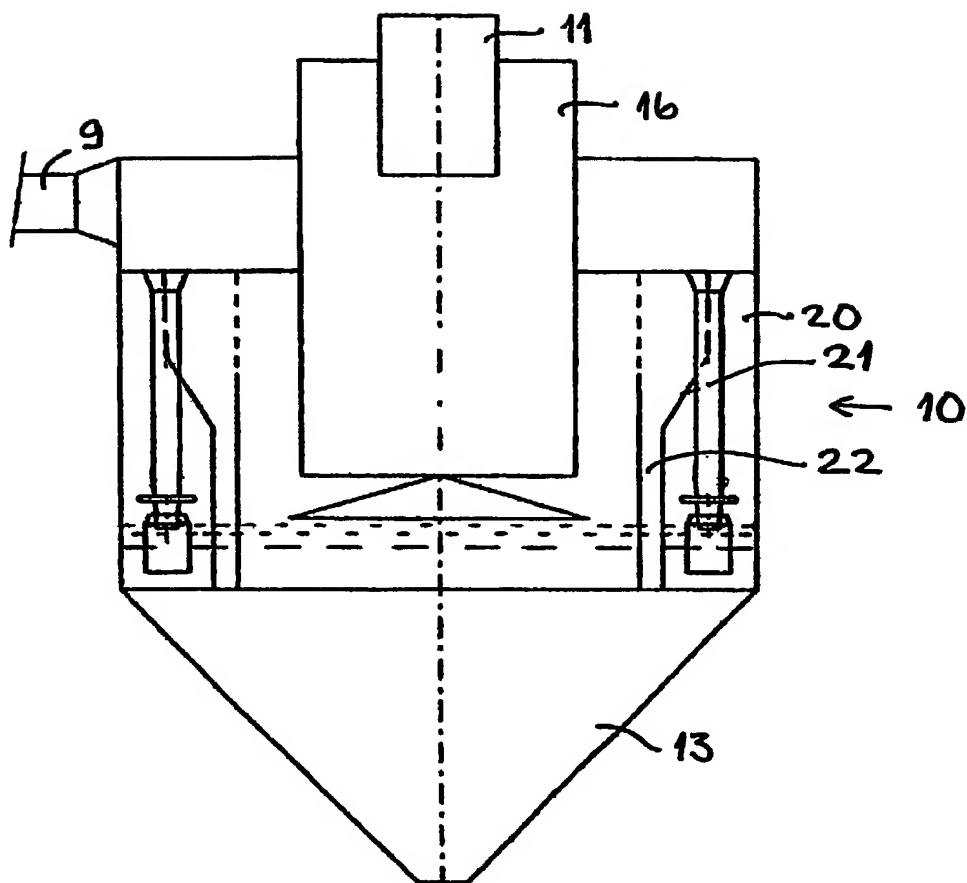


FIG. 5A

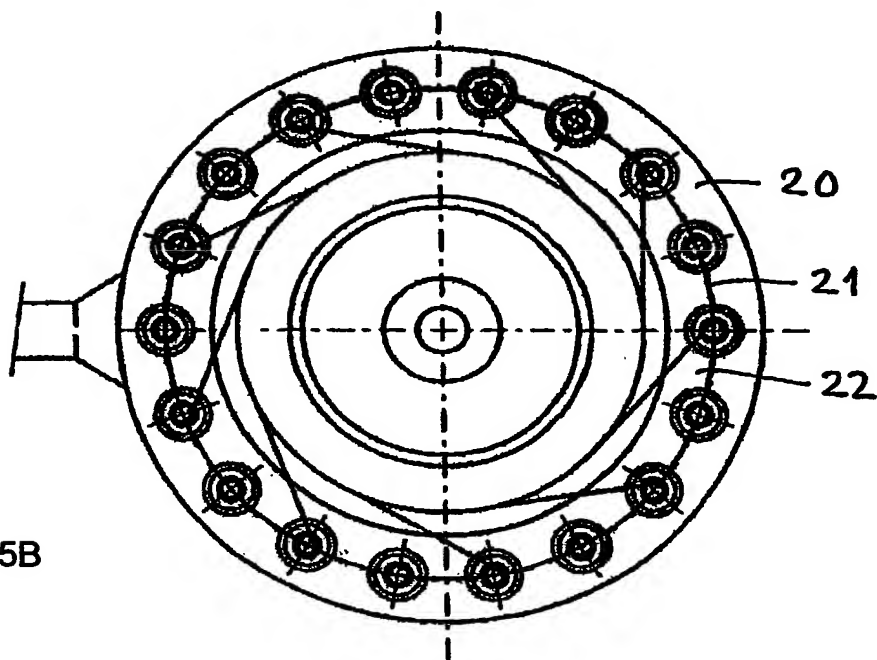


FIG. 5B

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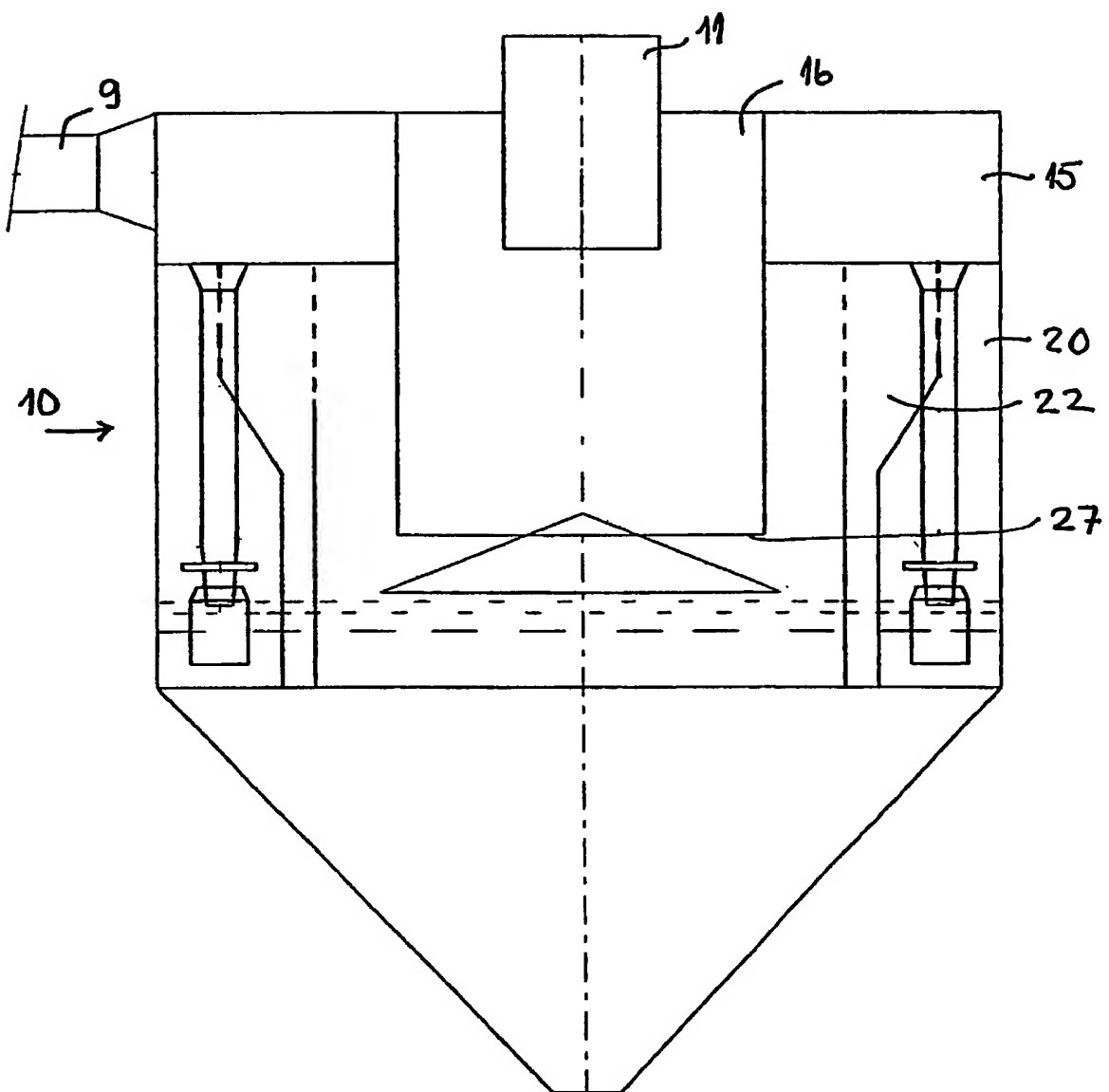


FIG. 6

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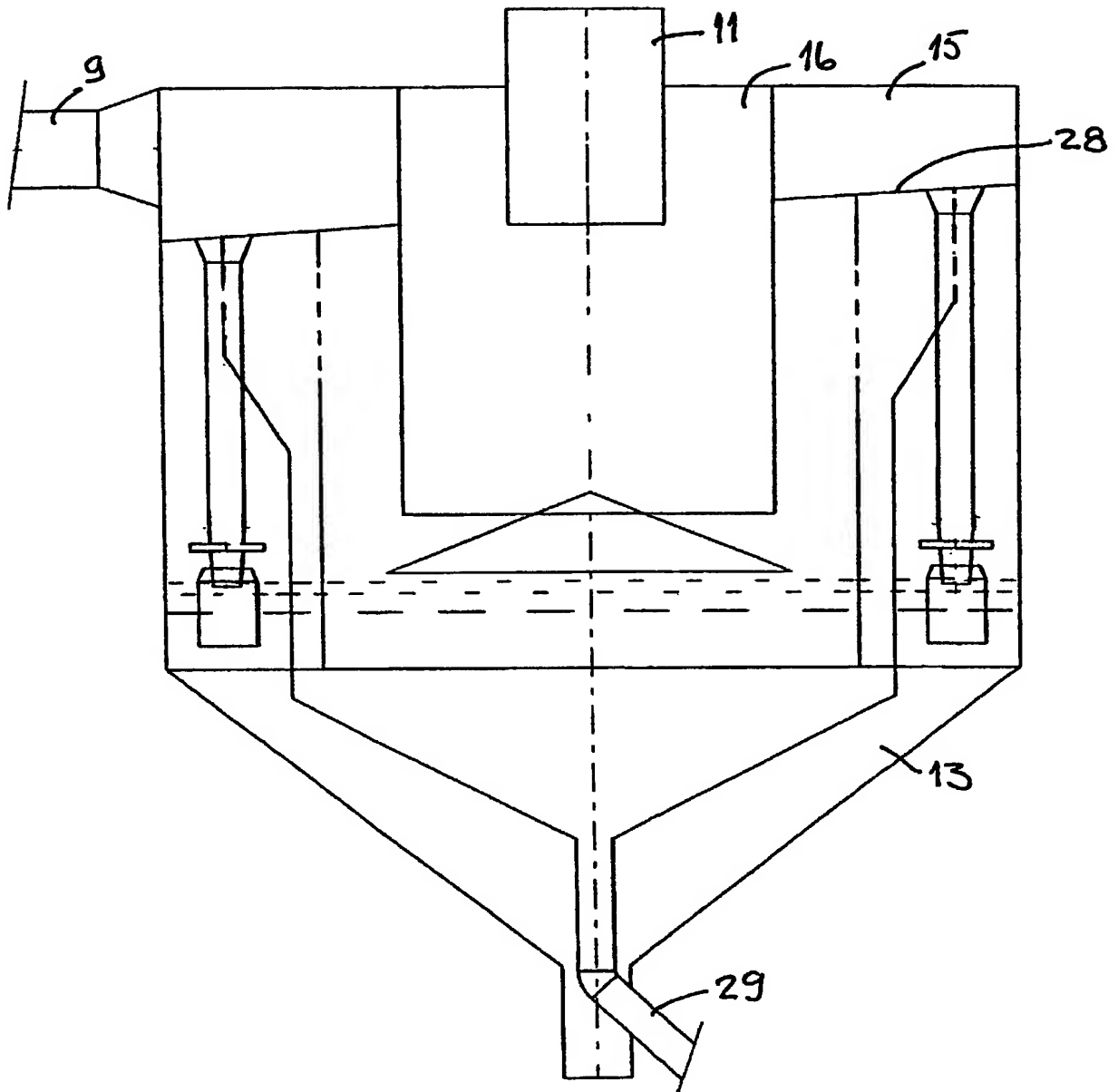


FIG. 7

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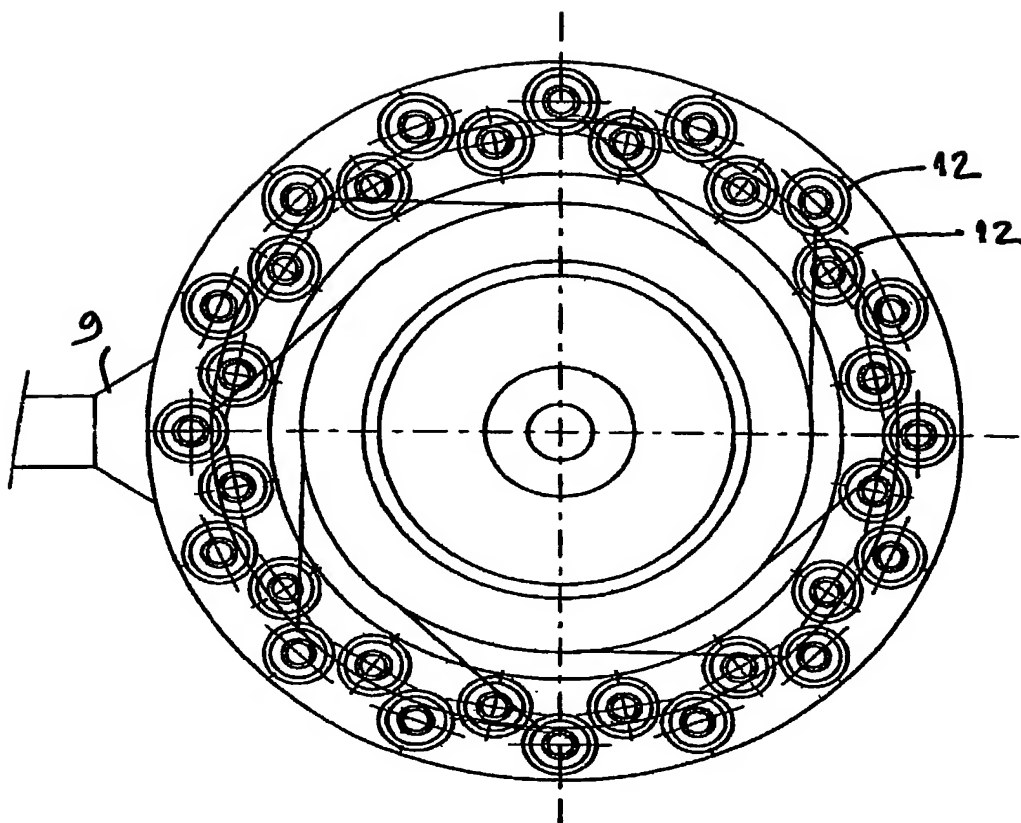


FIG. 8

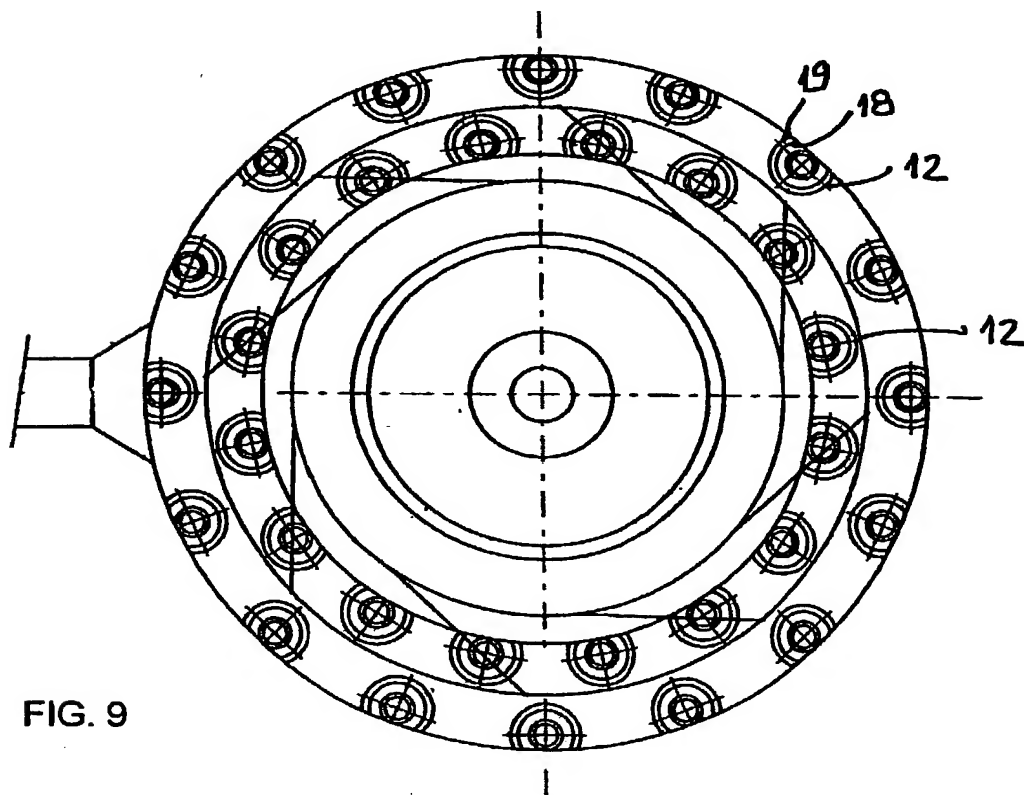
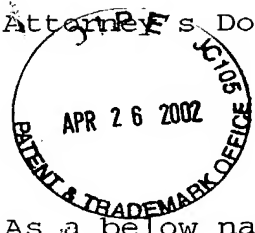


FIG. 9

1005555 1112602

99 2097 USA

Attorney's Docket No. _____



DECLARATION FOR PATENT APPLICATION
(COMBINED WITH POWER OF ATTORNEY)
(ORIGINAL APPLICATION)

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name. I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A compact cascade scrubber for scrubbing exhaust gas

the specification of which is attached hereto unless box (a) or (b) is checked, in which case

- (a) ☐ the specification was filed on _____ as Application No. _____.
- (b) ☒ the specification was filed as PCT International Application No. PCT/FI00/00834 filed on 29 Sep. 2000 and was amended under PCT Art. 19 on _____ (if any).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Sec. 1.56.

I have identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America and filed less than 12 months (6 months for designs) prior to this United States application and of which I claim foreign priority benefits under Title 35, United States Code, Sec. 119, and I have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

EARLIEST FOREIGN APPLICATION, AND ALL FOREIGN APPLICATIONS FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

<u>Country</u>	<u>Application No.</u>	<u>Date of Filing</u> (month/day/year)
Finland	19992097	30/09/1999

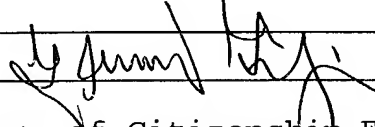
As a named inventor, I hereby appoint the practitioners associated with **Customer Number 007812** (John Smith-Hill, Reg. No. 27,730 and Daniel J. Bedell, Reg. No. 30,156) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent.

Send correspondence to the correspondence address associated with **Customer Number 007812**.

I hereby authorize the practitioners that I have appointed to accept instructions regarding this application and the resulting patent from OUTOKUMPU OYJ.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Title 18, United States Code, Sec. 1001, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

100 Full name of sole or first joint inventor Launo LILJA

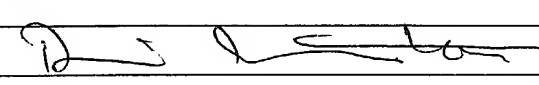
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3-00

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5-00

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Inventor's signature Bror Nyman

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Full name of sixth joint inventor, if any _____

Inventor's signature _____

Date _____ Country of Citizenship _____

Residence _____

Post Office Address _____

Full name of seventh joint inventor, if any _____

Inventor's signature _____

Date _____ Country of Citizenship _____

Residence _____

Post Office Address _____